Nutrient Management - Apples in China

A worksheet for Apple Extension workers.

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Manual Objective:

Be able to understand and estimate nutrient needs of an apple crop.

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Simple Calculation

(from Lailiang Cheng)

Element	Value	Comments (range)
Target Fruit yield	5000 kg per mu,	
Total N requirement for both the trees and for 5000 kg apples/mu	6 kg N per mu.	5-6 kg per mu
Typical fertilizer rate (e.g., 2012 in Qixia County)	90 kg N per mu	range 33 to 426 kg per mu
N from soil with 1-1.5% Soil organic matter	1 kg per mu	Approximate – SOM will provide about 20% of tree N requirement
N needed from fertilizer	5 kg N per mu	Total needed – N from soil = 6-1 =5 kg
Typical fertilizer recovery	40%	
Fertilizer need to provide 5 kg N/mu	12.5 kg N per mu	Fertilizer needed = (amount needed)/(fertilizer recovery) = 5/40%
Fertilizer wasted	77.5 kg N per mu	90 kg applied -12.5 kg needed
Money wasted/mu	Can be discussed in class	77.5 kg N/mu * cost N/kg

If rates are reduced, then this will

1) mitigate vigorous shoot growth to create more balanced trees and less pruning;
2) reduce fruit N level to improve fruit quality;
3) reduce the fertilizer cost for apple production; and
4) decrease the impact of apple production on the environment, particularly ground water.

All these aspects are related to the sustainability of apple production of China, which is a huge issue.

More detailed calculation

1. Nutrient removed in product

The key elements	The theory
What you need to know: Target yield Nutrient content in fruit Nutrient in fruit (kg N/ha) = yield target(FW) (kg/ha) x % nutrient content Dwt/100 x (100-MC%)/100	Givens (Source USDA) N 0.3% (Dwt) P 0.06 % (Dwt) K 0.8 % (Dwt) MC = Moisture content of fruit = 84% (= 16% dry weight) Considerations – Nutrient content is on a dry weight basis, but needs to be calculated for a fresh weight yield.

Example

Target yield = 10,000 kg/ha (Fresh weight)
Assume MC = 84%

Nitrogen removed in fruit kg N/ha
= yield target(FW) (kg/ha) x % nutrient content Dwt/100 x (100-MC%)/100
= 10,000 kg/ha x 0.3/100 x (100-84)/100 = 4.8 kg N/ha
Phosphorus kg P/ha = 1 kg P/ha
Potassium in fruit kg/ha = 12.8 kg K/ha

Practice

Target yield = 40,000 kg/ha

Nutrient removed in fruit (kg N/ha)
= yield target(FW) (kg/ha) x % nutrient content Dwt/100 x (100-MC%)/100

N = 40,000 (kg/ha) x % nutrient content Dwt _____/100 x (100-84%)/100

= _____ kg/ha

P = 40,000 (kg/ha) x % nutrient content Dwt _____/100 x (100-84%)/100

= _____ kg/ha

K = 40,000 (kg/ha) x % nutrient content Dwt _____/100 x (100-84%)/100

= _____ kg/ha

2. Total nutrient demand

The key elements	The theory
Total nutrient demand depends on target yield	Total nutrient demand kg/ha = Fruit N/38.5%

Example

Target yield 40,000 kg/ha

Total nitrogen demand = Fruit N/ 38.5%

Fruit demand for target yield (from previous example) = 19.2 kg N /ha

Therefore, total N demand = 19.2 kg N /ha /0.385 = 49.9 kg N/ha

Practice

Target yield 35,000 kg/ha

Nitrogen required in fruit + canopy =

1. Calculate N required in the fruit (= yield target(FW) (kg/ha) x % nutrient content Dwt/100 x (100-MC%)/100)

2. Calculate total N required based on N in fruit

3. Nutrient Sources

3.1. Soil (Nitrogen from soil organic matter)

It is known these figures are not exact, but they give a good indication for typical soils of expected N release.

The key elements	The theory and assumptions
SOM kg per ha = Soil weight kg/ha x %SOM Total N in Soil from SOM = Weight soil x % SOM x %N in SOM	**Weight SOM in soil** Assume SOM to 15 cm or 20 cm Assume BD 1.2 Soil weight per ha to d cm = 10,000 sq m/ha x 10,000 sq cm/sq m x depth cm x Bulk density g/cu cm x 1/1,000 g/kg = soil weight in kg Gives Soil weight kg/15cm ha) = 10,000 sq m/ha x 10,000 sq cm/sq m x 15 cm x 1.2 g/cu cm x 1/1,000 g/kg = 1,800,000 kg soil weight to 20 cm ha = 2,400,000 kg/ha **Composition of SOM** SOM = 58% C C:N ratio in equilibrium = 12:1 therefore SOM = 5% N **mineralization** 1.5% mineralization per year **Nitrogen uptake by okant from soil** Rates vary from 20-60% Assume 40 or 50%

Example
Note: Use Soil weight of 2,200,000 kg/ha

Weight of SOM in soil (kg/ha)
= Weight soil x % SOM kg/ha
If SOM = 1%, then, weight SOM (kg/ha) = 2,200,000 kg/ha x 1/100 = 22,000 kg

Weight Nitrogen in Soil for given amount of SOM
= Weight soil x % SOM x %N in SOM
If SOM = 1%, and SOM = 5% N, then
Weight nitrogen in soil (kg/ha) = 2,200,000 x 1% x 5% = 1,100 kg N total

Conclusion (Rule of thumb)

For each 1% SOM, the soil has a total N content of approximately 1,100 kg N

Mineralization (release) of Nitrogen from SOM

Mineralization of nitrogen from SOM varies from 0-5 % per year

A rate of around 1.5% for mineralization for an orchard is reaosnable

N released each year from the SOM

= soil weight kg/ha x SOM% x 5% N x 1.5% mineralization

If SOM = 1%, then

N released from SOM (kg/ha) – assuming 1.5 % mineralization

= soil weight kg/ha x SOM% x 5% N in SOM x 1.5% mineralization
= 2,200,000 kg /ha x 1% SOM x 5% N in SOM x 1.5% released
= 1,100 x 1.5%
= 16.5 kg N released per % SOM

Practice

What if SOM is 2.5 % and mineralization is 1.5% per year?

N released from SOM (kg/ha)

= 2,200,000 kg /ha x SOM% x 5% N in SOM x 1.5% mineralization

= _____

3.2 Nutrients from other sources: Aerial deposits and Nutrients from water?

Do nutrients enter the orchard from other sources? If so, estimate for:

Nitrogen from air deposits? _____

Nutrients from irrigation water? _____

Reduce fertilizer needs based on these other inputs.

4. Plant uptake

The key elements	The theory
Plants often only take up 40-50% of applied nitrogen or nitrogen released from organic sources	

Example

Approximately how much nitrogen might be taken up from a soil at 1% SOM?

Step 1. Nitrogen released from SOM?

From the previous example, at 1% SOM, there is approximately 16.5 kg N released per year.

Step 2. Nitrogen taken up by the plant?

40-50% of 16.5 kg N

= 7 to 8 kg N/ha uptake by the plant

Practice

What is the expected plant uptake if SOM = 2.5%

5. Fertilizer - Nutrients required from fertilizer

The key elements	The theory
Nutrients to add in fertilizer = total demand – (Nutrients from Soil + aerial deposits + water inputs)	

Example

Target yield = 40,000 (MC = 84%)
N content = 0.3 (Dwt)
SOM = 2%

Step 1. Calculate Nutrients needed in crop

Total nitrogen demand = Fruit N/ 38.5%
= 49.9 kg N/ha (from previous calculation)
≅ 50 kg N/ha

Step 2. Calculate nutrients provided by Soil
At 2% SOM, N from SOM = 33 kg/ha
But only 50% uptake = 33/2 ≅ 17 kg N/ha

Step 3. Calculate nutrients required from fertilizer
N to be added = total demand – uptake from soil supply = 50 - 17 = 33 kg N/ha

Step 4. Adjust for efficiency of uptake
N recovery is typically from 40-50 %

therefore
kg N/ha required from fertilizer
At 40% efficiency = 33/0.4= 82 kg N/ha
At 50% efficiency = 33/0.5 = 66 kg N/ha

Use average (66 + 82)/2 = 74 kg/ha

Practice

How much fertilizer is required for yield of 35,000 kg/ha with a SOM of 3%

6. Fertilizer type

Converting nutrient to fertilizer

Fertilizer required = Nutrient required kg/ha x 100/(% nutrient in fertilizer)

Example

The key elements	**The theory**
Fertilizer required kg/ha = Nutrient required kg/ha x 100/(nutrient content in fertilizer)	
Example Nitrogen required 74 kg/ha Urea = 46% N Fertilizer required kg/ha = Nutrient required kg/ha x 100/(% nutrient in fertilizer) Urea required kg/ha = 74 kg/ha x 100/(46) = 160 Urea kg/ha	
Practice How much Urea is required if 75 kg N are required How much Ammonium sulfate (21% N) is required	

7. Economics

How much yield do I have to see for my application

The key elements	The theory
Product needed to cover cost of fertilizer Product required (kg) = Kg fertilizer x fertilizer cost ($/kg fertilizer) x 1/(price apples ($/kg))	

Example

Givens:
Market price for apples = $0.25/kg
Cost urea = $0.5/kg urea
N required as fertilizer (allowing for 40% recovery) = 74 kg N/ha

Step 1. Calculate fertilizer required based on N required

Urea to apply kg/ha = Nutrient required/(content in fertilizer)
= 74/0.46 kg/ha = 160 kg urea/ha

Step 2. Convert cost of fertilizer to weight of apples

Apples required to pay for fertilizer
= Kg fertilizer applied x fertilizer cost ($/kg fertilizer) x 1/(price apples ($/kg))
= 160 kg urea/ha x $0.5/kg Urea x 1/($0.25/kg apples) = 320 kg apples

Practice

Market price for apples = $0.3/kg
Cost urea = $0.25/kg urea
N required as fertilizer = 60 kg N/ha

8. Timing of applications

The key elements				The theory
Element	**Budburst (+ 2 weeks)**	**Fruit set (Bloom/petal fall)**	**Harvest (+ 1 week)**	
N	30-40% total	30% total	30-40% total	
P				
K	40% total	30% total	30% total	
Example **When apply 125 kg/ha Urea?** Budburst 30% x 125 kg Urea/ha = 37.5 kg Urea/ha Fruit set 30% x 125 kg Urea/ha = 37.5 kg Urea/ha Postharvest 40% x 125 kg Urea/ha = 50 kg Urea/ha				
Practice				

Source (L Cheng and Yarra.us)

Picture Yara.us

9. What happens if I apply too much?

The key elements	The theory
High Nitrogen • reduces storage life • Reduces fruit color • Reduces flavor • results in excess leaf growth at the expense of fruit development. • can lead to more tree disease (e.g. fire blight), • reduced storability of fruit. • leads to increased Nitrogen runoff • increases costs – due to unnecessary fertilizer and increased labor for pruning	

10. Review

Calculate the amount of Urea fertilizer required for a yield of 25,000 kg/ha with a SOM of 1.5%

True or false: I should apply more nutrient than I need because fertilizer is cheap and I don't want to risk missing maximum yield?

True or false: I only need add nitrogen.

True of false: Too much nitrogen has no effect on apple quality or apple storage?

Answer the following

Why do I need to also apply P and K?

Too much nitrogen is money thrown away.

Too much nitrogen is bad for my soil and water?